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13. SUPPLEMENTARY NOTES

14. ABSTRACT
The US Army Research, Development and Engineering Command's (RDECOM) Aviation and Missile Research Development and Engineering Center's (AMRDEC) Manufacturing Science and Technology Division (MS&T) at Redstone Arsenal, AL, is engaged in a Ceramic Manufacturing Technology Program (CMTP). The objective of this effort is to assess current and newly developed ceramic machining technologies and 2) perform initial evaluation of various machining parameters and tooling.

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Ceramic Machining Evaluation

NCDMM Project No. NQ04-0001-02 Redstone

Technical Report

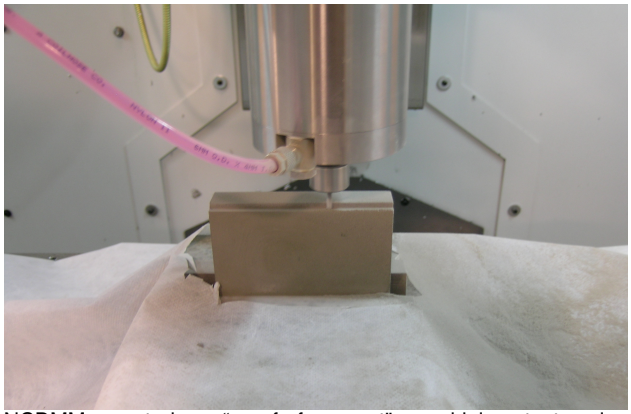
PROBLEM / OBJECTIVE

The US Army Research, Development and Engineering Command's (RDECOM) Aviation and Missile Research Development and Engineering Center's (AMRDEC) Manufacturing Science and Technology Division (MS&T) at Redstone Arsenal, AL, is engaged in a Ceramic Manufacturing Technology Program (CMTP). The objective of this effort is to 1) assess current and newly developed ceramic machining technologies and 2) perform initial evaluation of various machining parameters and tooling.

The light weight of ceramic materials and their outstanding resistance to wear and high temperatures make them increasingly preferred for industrial applications. However, machining ceramics is very costly and time consuming. Grinding, with its high cost and low volume material removal rate (MRR), is still the most common method used to finish machine sintered (fired) ceramic components [1].

New machining methods must be evaluated in order to produce ceramic components in a more timely, cost-effective manner.

ACCOMPLISHMENTS / PAYOFF



NCDMM created a "proof-of-concept" machining test using "bisque" silicon carbide and "bisque" silicon nitride ceramic material. All tests were performed on a Fryer MC-40 CNC machining center at NCDMM.

From the research conducted at NCDMM, most of the latest machining technologies for processing ceramic components focus on machining ceramic material after it has been sintered. Grinding, ultrasonic and rotary ultrasonic machining are among the most common methods used to finish sintered ceramic material. Laser assisted machining (LAM) shows some promise and has a higher MRR, but development of this technology is still in its infancy.

Process Improvement

The accompanying table of NCDMM test results shows that machining ceramic material in the pre-sintered "bisque" state using Polycrystalline Diamond (PCD) tools produced a higher MRR (up to 250 or 1000 times greater if compared to grinding, depending on endmill size used) than machining sintered ceramics using other methods.

Machining Ceramic Material	
Bisque (Unsintered) Machining	**MRR (in3/min [mm3/min])**
1/8" PCD Endmill	0.1500 [2458]
1/4" PCD Endmill	0.6000 [9832]
Finish (Sintered) Machining	~
Grinding	< 0.0006 [10]
Ultrasonic Machining (UM)	< 0.0031 [50]
Rot. Ultrasonic Mach (RUM)	< 0.0305 [500]
Laser Assisted Mach (LAM)	< 0.0610 [1000]
Reference	~
Turning Hardened Steels	~ 0.3051 [5000]

Therefore, to minimize the time and cost associated with finish machining after sintering, ceramic materials should be machined in the bisque state with PCD tooling whenever possible.

Expected Benefits

- Reduced operation time by 90% by rough machining in bisque state, when compared to grinding
- Reduced labor costs
- Increased competitiveness of ceramic components

TIME LINE / MILESTONE

Start Date.....October 04
End Date.....June 05

PROJECT FUNDING

NCDMM funding.....$ 100K

PARTICIPANTS

Fryer Machine Systems Inc.
Kennametal Inc.

1. H. Toenshoff, T. Lierse and I. Inaski, "Grinding of Advanced Ceramics" Machining of Ceramics and Composites, ed. S. Jahanmir et al, (New York-Basel, Marcel Decker, Inc.) 85-118 (1999).

For additional information concerning this project, contact the NCDMM at www.ncdmm.org